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Full Research Article

Influence of Mulch and Biofertilizer on Growth and Yield of Tomato

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Abstract

The present study comprised of three genotypes (V_1-Naveen 2000+, V_2-Sun-7711 and V_3-Solan Lalima), three mulches (M_0-No mulch, M_1-Pine needle mulch and M_2-black polyethylene) and three biofertilizers (B_0-recommended NPK, B_1-100% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1 g plant^{-1}) and B_2-75% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1 g plant^{-1}). Thus, there were 27 treatment combinations which were replicated thrice in split-split plot design. Among varieties, number of days to first flowering and first harvest and maximum yield was observed with the variety V_2 (Sun-7711). Among the mulch materials and biofertilizers, M_2 (Black polythene) and B_1 (100% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1 g plant^{-1}) were recorded to be the best regarding number of days to first flowering and first harvest and fruit yield. The first order interactions viz., varieties×mulch, biofertilizers×mulch and varieties×biofertilizers significantly affected most of the characters under study. Maximum fruit yield was obtained with treatment combinations of V_2M_2 (Sun-7711 applied with black polyethylene mulch), B_2M_2 (75% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1 g plant^{-1}) applied with black polyethylene mulch) and V_2B_2 (Sun-7711with 75% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1 g plant^{-1}). Further in three factor interaction, the highest fruit yield (1037.33 q ha^{-1}) was obtained with the treatment combination of Sun-7711, 75% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1 g plant^{-1}) and black polyethylene mulch ($V_2B_2M_2$).

1. Introduction

Tomato is one of the most important vegetable crops grown throughout the world. It is suggested that the name tomato came from the Nahutal Language of Mexico. Tomato is recognized globally for its nutraceutical values. It is a rich source of vitamin-A (4.04 mg 100 g^{-1}), vitamin-C (15-30 mg 100 g^{-1}), total soluble solids (4-7%), titratable acidity (7.5-10 mg 100 ml^{-1}) and lycopene content (20-50 mg 100 g^{-1}). It is cooked as a vegetable alone or mixed with other vegetables. The ripe fruits are taken as raw or made into salads, soups, preserve, pickles, ketchup, puree, paste and many other products (Chadha, 2012). In India tomato is grown an area of 8,76,410 hectares with a production of 17,848,160 MT. In Himachal Pradesh, tomato is being cultivated over an area of 10,000 hectares with total production of 400,000 MT (NHB, 2013). The excessive use of nitrogenous fertilizers and imbalanced use of other fertilizers has resulted in yield saturation and deterioration of soil health. Proper incorporation of bio-inoculants is of utmost importance in maintaining the fertility and productivity of agricultural soils (Yadav, 2009). Tomato farming has also the problem of low productivity due to inadequate soil moisture present in plant root zone at the time of critical growth stages, particularly in May-June, whereas, in tomato fruit production during rainy season, i.e. June-August, the high moisture availability poses a problem of luxuriant weed growth and increase the incidence of diseases. Hence, there is urgent need for use of mulches and application of biofertilizers to regulate the soil moisture and major nutrients to enhance the production and quality of tomato under open field condition.

2. Materials and Methods

The trial was conducted during 2011 and 2012 summer seasons at the Experimental Research Farm of Dr Y S Parmar U H F, Horticulture Research Station, Kandaghat, Solan situated 30-50^0 N latitude, 77.8^0 E longitude and 1435 m above mean sea level. The experiment comprised of three genotypes (V_1-

Naveen 2000+, V_2-Sun-7711 and V_3-Solan Lalima), three mulches (M_0-No mulch, M_1-Pine needle mulch and M_2- black polyethylene) and three biofertilizers (B_0-recommended NPK, B_1-100% NPK+*Azotobacter* (1g plant^{-1})+PSB (1g plant^{-1}) and B_2-75% NPK+*Azotobacter* (1g plant^{-1})+PSB (1g plant^{-1}). Thus, there were 27 treatment combinations which were replicated thrice in Split-Split Plot Design. Plants were transplanted on 2 April, 2011 and 4 April, 2012 at a spacing of 90×30 cm^2 in a plot having size 2.7×1.8 m^2, accommodating 18 plants per plot. Well rotten farm yard manure was applied directly to the soil based upon the nitrogen content of FYM which was applied @ 25 t ha^{-1} before transplanting. The complete dose of phosphorus and potassium and ⅓rd dose of nitrogen was applied at the time of field preparation as basal dose. However, the rest of nitrogen was applied in two equal doses viz. one month after transplanting and again two month after transplanting. These were applied through NPK grade complex (12:32:16) at the rate of 500 kg ha^{-1} and remaining quantity of nitrogen were given by calcium ammonium nitrate. Biofertilizers (*Azotobacter* and Phosphorus Solubilizing Bacteria-PSB) application was done through soil application @ 1g plant^{-1} by thoroughly mixed with FYM. The biofertilizers were applied as per the treatments assigned at the time of first earthing up i.e. 30-35 days after transplanting. Black polyethylene mulch of 50 µ (200 gauge thickness) and dry pine needle mulch were applied in plots according to the treatment combinations. The observations were recorded on number of days to first flowering, number of days to first harvest, harvest duration, number of fruits plant^{-1}, plant height (m) and highest yield (kg plant^{-1}, kg plot^{-1} and q ha^{-1}).

3. Results and Discussion

3.1. Number of days to first flowering and first harvest

The observation recorded on number of days to first flowering have been presented in Table (1a, 1b & 1c). In the individual effect, pooled analysis showed that the variety V_2 (Sun-7711) exhibited minimum number of days to first flowering and first harvest (41.24 and 66.20) while the variety V_3 (Solan Lalima) exhibited maximum number of days to first flowering and first harvest (45.56 and 73.76). This may be attributed to the genetic traits as reported by Zaman et al. (2011). Among the biofertilizers, minimum number of days to first flowering and first harvest (42.74 and 68.31) were taken by B_1, while B_0 took maximum number of days to first flowering (44.02) and first harvest (70.44). Earliness with the application of biofertilizers might be attributed to the faster enhancement of vegetative growth and availability of strong sufficient reserve food material for differentiation of vegetative buds into flowers (Kuppuswamy et al. 1992). The pooled data of various mulches used revealed that M_2 (Black polythene) recorded minimum number of days to first flowering and first harvest (42.46 and 68.09) and M_0 (No mulch) took maximum number of days to first flowering and first harvest (44.72 and 71.33). The early flowering and harvest under black polythene mulch might be due to better growth of plants as a result of high soil temperature and moisture. Hillel (1982) observed that the greater mulch

Table 1a: Effect of different mulches and biofertilizers on number of days to first flowering and first harvest, harvest duration and plant height of different genotypes in tomato

Treatment combination	Number of days to first flowering	Number of days to first harvest	Harvest duration (days)	Plant height (m)
	Pooled	Pooled	Pooled	Pooled
Varieties (V)				
V_1 (Naveen 2000+)	43.59	68.54	70.02	1.98
V_2 (Sun-7711)	41.24	66.20	81.83	2.20
V_3 (Solan Lalima)	45.56	73.76	74.80	2.26
CD (p=0.05)	0.78	1.42	0.99	0.01
Biofertilizers				
B_0 (NPK recommended)	44.02	70.44	74.11	2.09
B_1 (100% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1 g plant^{-1})	42.74	68.31	76.98	2.12
B_2 (75% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1g plant^{-1})	43.63	69.74	75.55	2.17
CD (p=0.05)	0.44	0.32	0.51	0.01
Mulches (M)				
M_0 (No Mulch)	44.72	71.33	74.25	2.00
M_1 (Pine needle)	43.20	69.07	75.59	2.12
M_2 (Black polyethylene)	42.46	68.09	76.79	2.32
CD (p=0.05)	0.48	0.48	0.31	0.01

thickness was more effective in preventing surface soil water evaporation which resulted in faster growth and early flowering of the plant. These results are in accordance with the findings of Nair (1999). The first order as well as second order interaction did not show any significant differences during both the years of study.

3.2. Harvest duration (days)

The results obtained on harvest duration, presented in Table (1a) show significant individual effect of varieties, biofertilizers and mulches. In the individual effect, pooled data analysis showed that the variety V_2 (Sun-7711) exhibited maximum harvest duration (81.83 days) while the variety V_1 (Naveen2000$^+$) recorded minimum harvest duration (70.02 days). This may be attributed to the genetic traits as reported by Kumar et al. (2004). Among different biofertilizers, B_1 recorded maximum harvest duration (76.98 days) and B_0 noticed minimum harvest duration (74.11 days). Longer harvest duration obtained by the use of biofertilizers might be attributed to longer vegetative growth. The possible reason for longer harvest duration may be the improvement in growth related attributes due to certain growth promoting substances secreted by biofertilizers, which might have led to better root and shoot development Chattoo et al. (2007). Similar results have also been reported in tomato by Thakur et al. (2010) and Singh (2012). Further, the pooled data analysis of different mulches revealed that maximum

Table 1b: Effect of different interactions V×B, B×M and V×M number of days to first flowering and first harvest, harvest duration and plant height in tomato

Treatment combination	Number of days to first flowering	Number of days to first harvest	Harvest duration (days)	Plant height (m)
	Pooled	Pooled	Pooled	Pooled
$V_1 B_0$	44.22	69.50	68.66	1.89
$V_1 B_1$	42.72	67.44	71.34	2.09
$V_1 B_2$	43.83	68.67	70.05	1.94
$V_2 B_0$	41.39	66.78	81.10	2.15
$V_2 B_1$	40.61	65.11	82.63	2.11
$V_2 B_2$	41.72	66.72	81.76	2.34
$V_3 B_0$	46.44	75.06	72.57	2.23
$V_3 B_1$	44.89	72.39	76.97	2.30
$V_3 B_2$	45.33	73.83	74.85	2.24
CD (p=0.05)	NS	NS	0.89	0.01
$B_0 M_0$	45.56	72.56	72.79	1.97
$B_0 M_1$	43.72	69.94	74.22	2.04
$B_0 M_2$	42.78	68.83	75.32	2.27
$B_1 M_0$	43.94	70.06	75.96	1.97
$B_1 M_1$	42.56	67.89	77.06	2.15
$B_1 M_2$	41.72	67.00	77.91	2.38
$B_2 M_0$	44.67	71.39	73.99	2.05
$B_2 M_1$	43.33	69.39	75.51	2.16
$B_2 M_2$	42.89	68.44	77.16	2.30
CD (p=0.05)	NS	NS	0.54	0.01
$V_1 M_0$	45.11	71.06	68.39	1.87
$V_1 M_1$	43.33	67.56	70.19	1.91
$V_1 M_2$	42.33	67.00	71.46	2.15
$V_2 M_0$	42.39	67.11	81.03	2.06
$V_2 M_1$	41.11	66.00	81.59	2.22
$V_2 M_2$	40.22	65.50	82.86	2.32
$V_3 M_0$	46.67	75.83	73.33	2.07
$V_3 M_1$	45.17	73.67	75.00	2.22
$V_3 M_2$	44.83	71.78	76.06	2.48
CD (p=0.05)	NS	NS	0.54	0.01

*NS=Non Significant

harvest duration (76.79 days) was obtained with M_2 (Black polythene) while M_0 (No mulch) recorded minimum harvest duration (74.25 days). The first order interactions V×B, B×M and V×M were also found significant for this character and results have been presented in Table 1b. In V×B interaction, treatment combination V_2B_1 registered maximum (82.63) days for harvest duration whereas minimum (68.66) was found with V_1B_0. The interaction effect between biofertilizers and mulches on this trait was found to be significant and the maximum harvest duration (77.91 days) was obtained with B_1M_2 and minimum (72.79 days) was recorded in B_0M_0. Further with regard to V×M, V_2M_2 exhibited maximum (82.86) days for harvest duration while V_1M_0 recorded minimum (68.39) days for this trait. Data in Table 1c clearly indicated the significant effect of V×B×M interaction on harvest duration of tomato fruit. Maximum harvest duration (83.16 days) was observed with treatment combination $V_2B_2M_2$. However minimum harvest duration (67.46 days) was recorded with treatment combination $V_1B_0M_0$.

3.3. Plant height (m)

The results obtained on plant height has been presented in Table (1a) which shows significant individual effect of varieties, biofertilizers and mulching. Individual effects, pooled data of both the years show that the variety V_3 (Solan Lalima) had maximum plant height (2.26 m) while V_1 (Naveen 2000$^+$) recorded minimum height of 1.98 m. This may be attributed to the genetic traits as reported by Zaman et al. (2011). Among different biofertilizers, B_2 recorded maximum plant height (2.17 m) and B_0 noticed minimum plant height (2.09

Table 1c: Effect of V×B×M interaction on number of days to first flowering and first harvest, harvest duration and plant height in tomato

Treatment combination	Number of days to first flowering	Number of days to first Harvest	Harvest duration (Days)	Plant height (m)
	Pooled	Pooled	Pooled	Pooled
$V_1B_0M_0$	46.00	72.67	67.46	1.76
$V_1B_0M_1$	43.83	68.50	68.46	1.81
$V_1B_0M_2$	42.83	67.33	70.05	2.11
$V_1B_1M_0$	44.17	69.67	69.28	1.99
$V_1B_1M_1$	42.50	66.50	72.13	2.06
$V_1B_1M_2$	41.50	66.17	72.60	2.22
$V_1B_2M_0$	45.17	70.83	68.44	1.80
$V_1B_2M_1$	43.67	67.67	69.99	1.89
$V_1B_2M_2$	42.67	67.50	71.72	2.12
$V_2B_0M_0$	42.67	67.67	80.09	2.01
$V_2B_0M_1$	41.50	66.50	81.09	2.17
$V_2B_0M_2$	40.00	66.17	82.13	2.26
$V_2B_1M_0$	41.83	66.00	82.40	1.87
$V_2B_1M_1$	40.33	65.00	82.18	2.17
$V_2B_1M_2$	39.67	64.33	83.16	2.30
$V_2B_2M_0$	42.67	67.67	80.60	2.30
$V_2B_2M_1$	41.50	66.50	81.51	2.32
$V_2B_2M_2$	41.00	66.00	83.31	2.39
$V_3B_0M_0$	48.00	77.33	70.83	2.08
$V_3B_0M_1$	45.83	74.83	73.10	2.18
$V_3B_0M_2$	45.50	73.00	73.78	2.42
$V_3B_1M_0$	45.83	74.50	76.22	2.06
$V_3B_1M_1$	44.83	72.17	76.87	2.23
$V_3B_1M_2$	44.00	70.50	77.81	2.61
$V_3B_2M_0$	46.17	75.67	72.95	2.06
$V_3B_2M_1$	44.83	74.00	75.02	2.25
$V_3B_2M_2$	45.00	71.83	76.60	2.40
CD (p=0.05)	NS	NS	0.93	0.02

*NS=Non Significant

m). The decomposition of organic matter by these microbial inoculants with the subsequent releases of available nutrients to the plants from the soil resulted in increased growth of the plants (Thakur et al., 2010). Another possible reason for increased plant height as result of biofertilizers application may be attributed to better proliferation of roots which helped in increased uptake of nutrients as well as plant growth hormones produced by microbes at root zone (Gajbhiye et al., 2003). Similarly plant height was significantly affected by various mulching treatments. The maximum plant height (2.32 m) was observed with black polythene mulch while M_0 (No mulch) gave minimum plant height (2.00 m). The possible reason may be more favourable soil moisture and more favorable conditions which produced vigorous growth during a comparatively shorter period (Grewal and Singh, 1974). Singh and Mishra (1973) reported maximum plant height under black polythene treatment which may be probably due to the increase in soil temperature and conserving more soil moisture. The increased plant height may be due to continuous availability of fertilizer nutrients throughout the crop growth period under ideal soil moisture regimes. The data in Table 1b revealed that in the interaction between variety and biofertilizers, treatment combination V_2B_2 recorded maximum plant height (2.34 m) which was statistically superior to all other treatments. Minimum value (1.89 m) was observed with V_1B_0. Further treatment combination B_1M_2 recorded maximum plant height (2.38 m), whereas minimum (1.97 m) was found with B_0M_0. In the interaction between variety and mulch treatment combination V_3M_2 recorded maximum plant height (2.48 m) and was found statistically superior to all other treatments.V_1M_o recorded minimum value (1.87 m) for this trait. The second order interaction between different varieties, biofertilizers and mulch materials had also significant differences for plant height (Table 1c). The pooled analysis of data in the experiment of both the years revealed that maximum plant height (2.61 m) was obtained with treatment combination $V_3B_1M_2$. Minimum plant height (1.76 m) was recorded with treatment combination $V_1B_0M_0$.

3.4. Number of fruits plant^{-1}

The results obtained on number of fruits plant^{-1} have been presented in Table (2a) which shows significant effect of varieties, biofertilizers and mulch. The pooled data of both the years show that the variety V_3 (Solan Lalima) recorded maximum number of fruits plant^{-1} (38.00) while minimum (29.85) was recorded with V_1 (Naveen 2000$^+$). This may be attributed to the genetic traits as reported by Kumar et al. (2004). Similarly number of fruits plant^{-1} was significantly affected by biofertilizers. The maximum number of fruits plant^{-1} (38.01) was observed with B_2, while B_0 recorded minimum number of fruits plant^{-1} (29.99). The possible reason may be better proliferation of roots in organic manure, which helped in increased uptake of nutrients as well as plant growth hormones produced by microbes at root zone and also enhanced biological nitrogen fixation by the application of biofertilizers (Thakur et al., 2010 and Gajbhiye et al., 2003). With regard to mulches, M_2 (Black polythene) recorded maximum number of fruits plant^{-1} (36.16) while minimum (32.67) was observed with M_0 (No mulch). The increased fruit number with black polythene mulch resulted in lesser weed number, less nutrient loss through leaching, thereby, resulting more fruits plant^{-1} (Bala, 2012). Increase in fruit number with the use of black polythene mulch

Table 2a: Effect of different mulches and biofertilizers on different yield parameters of different genotypes in tomato

Treatment combination	Number of fruit plant^{-1}	Yield (kg plant^{-1})	Yield (kg plot^{-1})	Yield (q ha^{-1})
	Pooled	Pooled	Pooled	Pooled
Varieties (V)				
V_1 (Naveen 2000$^+$)	29.85	2.34	42.07	692.47
V_2 (Sun-7711)	35.66	3.00	54.08	890.13
V_3 (Solan Lalima)	38.00	2.51	45.20	744.02
CD (p=0.05)	0.10	0.06	0.10	1.61
Biofertilizers				
B_0 (NPK recommended)	29.99	2.22	40.04	659.14
B_1 (100% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1 g plant^{-1})	35.50	2.76	49.61	816.61
B_2 (75% NPK+*Azotobacter* (1 g plant^{-1})+PSB (1g plant^{-1})	38.01	2.87	51.69	850.86
CD (p=0.05)	0.11	0.05	0.15	4.53
Mulches (M)				
M_0 (No Mulch)	32.67	2.39	42.93	706.61
M_1 (Pine needle)	34.67	2.64	47.45	781.10
M_2 (Black polyethylene)	36.16	2.83	50.96	838.90
CD (p=0.05)	0.13	0.03	0.17	2.75

was also reported by Singh (2005). In V×B interaction, V_3B_2 gave the maximum number of fruits plant^{-1} (41.43) which was followed by V_2B_2 and V_3B_1 recording 39.14 and 39.12 number of fruits plant^{-1}. Biofertilizers and mulch interaction were also found significant for this traits. The maximum number of fruits plant^{-1} (39.80) was recorded with B_2M_2 which was followed by B_2M_1 and B_1M_2 recording 38.39 and 37.28 number of fruits plant^{-1} respectively. The V×M interaction was significant during both the year of study. The pooled data analysis show that V_3M_2 recorded maximum number of fruits plant^{-1} (39.82) while the interaction V_1M_0 recorded minimum number of fruits plant^{-1} (28.30). Regarding the second order interactions, i.e. V×B×M, the maximum number of fruits plant^{-1} (43.34) was recorded with $V_3B_1M_2$ while the minimum number of fruits plant^{-1} (24.04) was recorded with $V_1B_0M_0$.

3.5. Yield

The results obtained on fruit yield has been presented in Table (2a) which shows significant individual effect of varieties, biofertilizers and mulches. Highest fruit yield (3.00 kg plant^{-1}, 54.08 kg plot^{-1} and 890.13 q ha^{-1}) was observed with V_2 (Sun-7711) while lowest yield (2.34 kg plant^{-1}, 42.07 kg plot^{-1} and 692.47 q ha^{-1}) was recorded with V_1 (Naveen 2000$^+$). The varietal effect may be attributed to its growth habit governed by genetic traits (Kumar et al., 2004 and Zaman et al., 2011). Biofertilizers affected the fruit yield significantly and B_2 recorded the highest yield (2.87 kg plant^{-1}, 51.69 kg plot^{-1} and 850.86 q ha^{-1}) while the lowest yield (2.22 kg plant^{-1}, 40.04 kg plot^{-1} and 659.14 q ha^{-1}) was observed with B_0. Optimum supply of nutrients resulted in better absorption of water and nutrients along with improved physical environment, which ultimately

Table 2b: Effect of different interactions V×B, B×M and V×M on different yield parameters of different genotypes in tomato

Treatment combination	Number of fruit plant^{-1}	Yield (kg plant^{-1})	Yield (kg plot^{-1})	Yield (q ha^{-1})
	Pooled	Pooled	Pooled	Pooled
V_1B_0	25.11	1.92	34.56	568.96
V_1B_1	30.97	2.49	44.85	738.23
V_1B_2	33.46	2.60	46.79	770.21
V_2B_0	31.41	2.60	46.85	771.23
V_2B_1	36.41	3.13	56.29	926.63
V_2B_2	39.14	3.28	59.08	972.52
V_3B_0	33.44	2.15	38.71	637.24
V_3B_1	39.12	2.65	47.69	784.96
V_3B_2	41.43	2.73	49.20	809.85
CD (p=0.05)	0.18	0.05	0.27	4.38
B_0M_0	28.53	2.05	36.94	608.04
B_0M_1	30.02	2.23	40.10	660.16
B_0M_2	31.41	2.39	43.09	709.23
B_1M_0	33.63	2.50	44.92	739.43
B_1M_1	35.59	2.77	49.88	821.09
B_1M_2	37.28	3.00	54.02	889.30
B_2M_0	35.83	2.61	46.92	772.35
B_2M_1	38.39	2.91	52.37	862.06
B_2M_2	39.80	3.10	55.78	918.18
CD (p=0.05)	0.22	0.19	0.29	4.76
V_1M_0	28.30	2.13	38.30	630.42
V_1M_1	29.87	2.35	42.27	695.80
V_1M_2	31.38	2.54	45.63	751.19
V_2M_0	34.04	2.79	50.18	825.97
V_2M_1	35.63	3.01	54.15	891.32
V_2M_2	37.30	3.22	57.90	953.09
V_3M_0	35.66	2.24	40.30	663.43
V_3M_1	38.50	2.55	45.94	756.20
V_3M_2	39.82	2.74	49.35	812.43
CD (p=0.05)	0.32	0.12	0.39	5.76

enhanced fruit yield (Thakur et al., 2010). Sharma et al. (2010) reported increased yield with biofertilizers application which might be due to better nutritional environment in the root zone which accelerated the process of cell division and hence fruit yield. The possible reason for increased fruit yield might be associated to better organic nitrogen utilization in the presence of biofertilizers, which enhanced biological nitrogen fixation, better development of root system and possible higher synthesis of plant growth hormones (Gajbhiye et al., 2003). Among various mulches, M_2 (Black polythene) showed the highest yield (2.83 kg plant^{-1}, 50.96 kg plot^{-1} and 838.90 q ha^{-1}) while least yield (2.39 kg plant^{-1}, 42.93 kg plot^{-1} and 706.61 q ha^{-1}) was observed with M_0 (No mulch). The increased yield under black polythene mulch have been reported by Hedau et al. (2001) and Bala (2012). The increase in yield may be attributed due to higher soil temperature which improved the plant micro-climate, thus, helping in maximum plant growth and fruit setting in tomato. Similar findings were reported by Channabavanna et al. (1989) and Ubaidullah Jan et al. (2002). In V×B interactions, V_2B_2 gave the maximum yield (3.28 kg plant^{-1}, 59.08 kg plot^{-1} and 972.52 q ha^{-1}). V_1B_0 treatment combination registered minimum yield (1.92 kg plant^{-1}, 34.56 kg plot^{-1} and 568.96 q ha^{-1}). With regard to B×M interactions, B_2M_2 gave maximum yield (3.10 kg plant^{-1}, 55.78 kg plot^{-1} and 918.18 q ha^{-1}). Minimum yield (2.05 kg plant^{-1}, 36.94 kg plot^{-1}, 608.04 q ha^{-1}) was registered with B_0M_0. Further, the treatment combination V_2M_2 recorded maximum yield (3.22 kg plant^{-1}, 57.90 kg plot^{-1} and 953.09 q ha^{-1}), whereas, minimum yield (2.13 kg plant^{-1}, 38.30 kg plot^{-1}, 630.42 q ha^{-1}) was found with V_1M_0. In second order interaction, the treatment combination $V_2B_2M_2$ recorded maximum yield (3.50 kg plant^{-1}, 63.02 kg plot^{-1} and 1037.33 q ha^{-1}) which was followed by combination $V_2B_1M_2$ (3.35 kg plant^{-1}, 60.26 kg plot^{-1} and 978.22 q ha^{-1}). The minimum yield was found in $V_1B_0M_0$ (1.78 kg plant^{-1}, 32.03

Table 2c: Effect of V×B×M interaction on different yield parameters of different genotypes in tomato

Treatment combination	Number of fruit plant^{-1}	Yield (kg plant^{-1})	Yield (kg plot^{-1})	Yield (q ha^{-1})
	Pooled	Pooled	Pooled	Pooled
$V_1B_0M_0$	24.04	1.78	32.03	527.27
$V_1B_0M_1$	25.30	1.93	34.70	571.12
$V_1B_0M_2$	26.00	2.05	36.97	608.51
$V_1B_1M_0$	29.26	2.24	40.32	663.70
$V_1B_1M_1$	30.81	2.50	44.92	739.41
$V_1B_1M_2$	32.85	2.74	49.30	811.58
$V_1B_2M_0$	31.59	2.36	42.54	700.29
$V_1B_2M_1$	33.52	2.62	47.19	776.86
$V_1B_2M_2$	35.28	2.81	50.63	833.49
$V_2B_0M_0$	29.75	2.40	43.20	711.18
$V_2B_0M_1$	31.35	2.61	46.94	772.59
$V_2B_0M_2$	33.13	2.80	50.42	829.92
$V_2B_1M_0$	34.98	2.92	52.53	864.69
$V_2B_1M_1$	36.29	3.12	56.08	923.17
$V_2B_1M_2$	37.98	3.35	60.26	992.01
$V_2B_2M_0$	37.39	3.04	54.80	902.03
$V_2B_2M_1$	39.25	3.30	59.43	978.20
$V_2B_2M_2$	40.78	3.50	63.02	1037.33
$V_3B_0M_0$	31.81	1.98	35.58	585.67
$V_3B_0M_1$	33.41	2.15	38.68	636.78
$V_3B_0M_2$	35.09	2.33	41.87	689.26
$V_3B_1M_0$	36.66	2.33	41.91	689.89
$V_3B_1M_1$	39.68	2.70	48.64	800.69
$V_3B_1M_2$	43.34	2.92	52.51	864.32
$V_3B_2M_0$	38.52	2.41	43.42	714.72
$V_3B_2M_1$	42.42	2.81	50.49	831.11
$V_3B_2M_2$	41.03	2.98	53.68	883.70
CD (p=0.05)	0.38	0.03	1.50	8.26

kg plot^{-1} and 527.27 q ha^{-1}).

4. Conclusion

The performance of variety V_2 (Sun-7711) was found best in days to first flowering, first harvest, maximum harvest duration and yield. Among the biofertilizers and mulch material used B_2 (75% NPK+Azotobacter (1 g plant^{-1})+PSB (1 g plant^{-1}) and M_2 (Black polythene) were recorded to be the best regarding the days to flowering and harvest as well as different yield parameters of tomato.

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